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MULTI-TARGET TRACKING - PHASE II

TASK I - FINAL REPORT

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TASK I FINAL REPORT

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1 INTRODUCTION

The main objective of this phase of the project is to investigate alternative track initiation techniques which can be simulated and tested in the context of the ATP software environment. As a result of this work, the new track initiation modules will be developed and integrated in the framework of the ATP package. The performance of the new track initiation algorithms in a dense clutter environment will be evaluated and documented in the form of a report containing the simulation output and results of the analysis.

1.1 Overview of the ATP Package

The Radar Division of DREO has developed Multi-Target Tracking software referred to as Automatic Tracking Program (ATP) package, in order to test the different tracking algorithms by using the real time radar data.

The ATP software package is written in VAX FORTRAN and is built around a framework program (FRAME) which calls all the necessary routines for complete automatic tracking operations. The routines called by the FRAME program include:

(a) Tracking Operation Set Up (SETUP)
(b) Radar Data Input (RSIM)
(c) Plot-to-Track Association (CORR)
(d) Track Initiation / Termination (INIT)
(e) Filtering (FILT)
(f) Display (DISP); and
(g) Tracking Statistics (LOG)

The functional breakdown of the ATP package is given in Annex A.

1.2 Performance Goals

The modified ATP package must offer all the current functionalities of the following ATP software modules:

(a) Tracking Operation Set Up (SETUP)
(b) Radar Data Input (RSIM)
(c) Plot-to-Track Association (CORR)
(d) Filtering (FILT)
(e) Display (DISP); and
(f) Tracking Statistics (LOG)

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The modified ATP package must provide the following additional futures:

(a) Improved Track Initiation Modules (INIT):

- Track Initiation based on Hough Transform
- Track Initiation based on Sequential Processing

(b) Processing in a dense clutter environment:
The array sizes will be increased to process more tracks and returns per scan.

The new INIT modules will have compatible interfaces with the current INIT module and will work with all the other existing modules of ATP package.

1.3 Technical Risks

In order to evaluate the performances of the new INIT modules in the heavily cluttered environment, the array sizes should be increased. This would also increase the requirement for the size of the memory storage.

The memory storage available on the platform limits the processing capability of ATP software package.

2 FUNCTIONAL REQUIREMENTS

2.1 Interfaces

2.1.1 External Interfaces

The CASE.DAT file provides the interface between the user and the ATP software environment. The information required by the tracker for a specific run is stored in the CASE.DAT file. This file is read at the beginning of the execution by the SETUP routine.

The other external interfaces, the radar data file and the Log file will remain unchanged.

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2.1.2 Internal Interfaces

FRAME - RSIM Interface

RSIM module reads a file containing the plot extracted data and stores the plots for the current scan in an array defined as:

A(0:50, 0:50, 10)

The structure of this array will be modified to incorporate the new track initiation modules to the ATP package. The definition for the array of A will be modified as:

A(0:size, 15)

The first dimension of the array will be increased from 50 to a number up to 500 to handle the dense clutter. The size will not be a hard-coded number to provide user the flexibility of simulating environments with different clutter density.

This array will also keep the number of the plots per scan and a in-use flag for each plot, in the locations A(0,1) and A(I, 10) respectively, where I > 0.

FRAME - CORR Interface

The interface between the modules FRAME and CORR is the array of A described above.

FRAME - INIT Interface

In the current version of the ATP package this interface includes:

* Returns from the current scan (A or B);
* Returns from the previous scan (A or B); and
* New track information (NEW_TRACKS).

Note that A and B arrays are used interchangeably to store the returns from the current and previous scans. These arrays are defined as

A(0:50, 0:50, 10), B(0:50, 0:50, 10)

to accommodate the different combinations of the distances between the plots from two consecutive scans.

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New track initiation routines which will be developed for this phase of the project require a different declaration of the return array and the old_return array. However, in order to use different INIT routines in the same ATP environment, the interface between the INIT routines and the FRAME module should be the same. This requires some changes in the current version of the INIT code.

The new interface includes:

* Information on the returns for the current scan (defined in the FRAME-RSIM Interface); and

* Information on the new tracks created by the INIT module. The new tracks are stored in NEW_TRACKS array by the INIT module. The structure of this array will remain unchanged. However, the size will be increased to handle the dense clutter environment.

FRAME - ADD Interface

The NEW_TRACKS array provides an interface between these two modules. The structure of the NEW_TRACKS array will remain unchanged. (The size will be increased.)

FRAME - DISP Interface

The interface between the modules FRAME and CORR is the array A(0:500, 15), as described in the FRAME - RSIM Interface Section.

2.2 Operating Functions

Two new track initiation techniques will be designed and implemented as alternative approaches to the track initiation algorithm currently used by ATP package:

* Track initiation based on the Hough Transform; and

* Track initiation based on sequential processing.

In order to evaluate the new techniques in a dense clutter environment against future radar data, the array sizes will be modified to increase the capability of processing up to 500 new returns per scan and 500 tracks.
In order to satisfy this requirement, the sizes of the arrays which keep the plots from the current scan and from the previous scan have to be modified.

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The sizes of the arrays which keep the existing tracks and the potential new tracks will be changed from 100 and 50 to 800 and 500 respectively.

The track initiation modules; both designed for this phase of the project and the one currently available in the ATP package, will be used in the frame (FRAME) while keeping all the other functionalities of the other tracking modules unchanged. This method provides the means to evaluate the performance of a specific track initiation technique.

In order to provide this capability, the INIT - FRAME interface must be compatible for different INIT modules. This requires some changes on interface structures which keep the plots from the current scan as described in the Internal Interfaces section. The section 2.2.1 describes the modification required on the other modules of the ATP package due to the INIT-FRAME interface changes. The version including the modification described in section 2.2.1 will be used as a baseline test-bed to develop the other track initiation routines.

Section 2.2.2 and 2.2.3 describe the new track initiation techniques and the required functionality changes in the ATP package.

2.2.1 Modifications on the Existing Modules of the ATP

In the current version of the ATP program, arrays of A(0:50, 0:50, 10) and B(0:50, 0:50,10) are used interchangeably to keep the radar plots from the previous and the current scan. These arrays also keep the number of the plots for each scan and an in-use flag for each radar plot.

The array of A(0:50, 0:50, 10) will be used to keep only the data from the current scan and modified to

A(0:500, 15)

A(0,1) will keep the number of the plots per scan.

A(I,J) will keep the plot data, where I > 0 and J changes from 1 to 9.

A(I,10) will keep the in-use flag for each plot, where I > 0.

Note that in the current version of ATP, this location corresponds to the locations A(0,0,1), A(I,0,J) and A(I,1,1) respectively where I > 0 and J changes from 1 to 9.

The array of B(0:50, 0:50, 10) will be used to keep the radar plots from the previous scan. The required structure of this array changes with the initiation techniques used. This arises the need for each INIT module to maintain its own B array to keep the plots from the previous scan.

The structure of B array will remain the same for the track initiation module currently used in ATP package. However, it will only be dedicated to the plots from the previous scan and the size will be increased from 50 to 500 to process dense clutter radar data, B(0:500,0:500, 10).

The INIT modules to be designed for the Phase II of the project, will require different structures for the B array. These structures will be described in Section.

The modifications on the array structures of A and B require some changes in the current version of the ATP code. The modules effected by these changes are:

- FRAME;
- RSIM;
- CORR;
- INIT (current version); and
- DISP.

FRAME Module

FRAME module checks FLAG variable to determine either A or B is the array which keeps the plots form the current scan since these arrays are used interchangeably to keep the data from the previous and the current scans. This check is not necessary any more. Only the A array will be used to keep the radar plots from the current scan.The B array will keep the previous scan data and maintained by the INIT modules.

This module will only pass the A array to the other modules of the ATP package for further tracking processing.

RSIM, CORR and DISP Modules

RSIM module reads radar data file and stores the measurements in the array passed by the FRAME module. In the current version, this array is either A or B (having the structure (0:50, 0:50, 10)) depending on the variable flag.

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CORR routine correlates the measurements from the current scan to the existing tracks. In the current version, the measurements from the current scan are passed by the FRAME module in either A or B array.

DISP routine uses the returns from the current scan. (either A or B array passed by FRAME module, in the current version).

The parts of the code which accesses and manipulates the array which keeps the returns from the current scan has to be modified since the FRAME will only pass the A array and the structure of the A array is changed.

INIT Module

In the current version of ATP, this routine accepts returns from the current scan (either A or B array), returns from the previous scan (either A or B array) and the NEW_TRACKS array as its inputs. For the sake of compatibility with the other INIT modules to be designed, in the modified version, the FRAME module will only pass the returns from the current scan (in the A(0:500, 15) array) and the NEW_TRACKS array. However, the returns array has to be converted to the old format (0:500, 0:500,10) to be used by the INIT module. For this purpose, INIT will call a conversion routine before doing any initiation process. This conversion routine will convert the A(0:500, 15) to A_INIT(0:500, 0:500, 15) as described in the following:

A (0:500, 15) Array	A_INIT(0:500, 0:500, 10) Array
A(I,1) - A(I,9)	A_INIT(I,0,1) - A_INIT(I,0,9)
A(I,10)	A_INIT(I,1,1)
A(0,1)	A_INIT(0,0,1)

where $I > 0$.

After the track initiation process, before returning to the FRAME code, this module will copy the returns from this scan to the array which keeps the returns from the previous scan in the format of (0:500, 0:500, 10).

2.2.2 Track Initialization Based on Hough Transform

This technique is based on the representation of all points (x_i, y_i) along a straight line in the form of

$$x_i \cos\theta_o + y_i \sin\theta_o = \rho_o$$

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where θ_o is the angle of the normal with the x-axis and ρ_o is the perpendicular distance of the line from the origin.

Each point (x,y) in the x-y plane can be mapped into a curve in the θ-ρ plane defined by the general relationship

$$x\cos\theta + y\sin\theta = \rho$$

A number of curves in θ-ρ plane, generated by a set of points from the straight line will intersect at the point (θ_o,ρ_o). Thus, a group of points in the x - y plane that all lead to a common point (θ_o,ρ_o) in the θ_o - ρ_o plane can be identified as a straight line.

θ is restricted between 0° and 180°, so that the normal parameters for the line can be unique and θ and ρ can be always bounded. A two dimensional histogram is formed using parameter spacing $\Delta\theta$ and $\Delta\rho$. Then thresholding is used to determine the target presence within any of the $\Delta\theta$ - $\Delta\rho$ bins.

The total number of increments in the θ parameter (N) and the centre points of the histogram bins are defined as

$$N = \frac{\pi}{\Delta\theta} \qquad \theta_{bin} = (N_\theta - \frac{1}{2})\Delta\theta$$

Points on a straight line will contribute mostly to the same or adjacent bins. On the other hand, for the random points the contributions will be spread over the bins. Thus, after accumulation, the number of points within each bin will be compared with a threshold and a track is declared if the threshold is exceeded.

This technique is used for identifying straight-line trajectories against a heavy clutter background. The extensions to other type of curves and to higher dimensional spaces is possible but require more computations.

INIT Routine

A new initialization routine (INIT) will be written to incorporate the Hough transform initialization technique to the ATP package.

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Inputs:

(1) Unused plots from the previous scans (not associated with any tracks in the global track database); and

(2) Unused plots from the current scan (not associated with any tracks in the global track database).

The information on the unassociated plots from the current scan and previous 4-5 scans (this number will be determined in a later stage) will be kept in the table. The address of this table will be passed to the INIT routine. The information stored in this table corresponding to each plot can be listed as:

(a) Measurement data (data read form the radar data file)

- Range (nmi);
- Azimuth (deg);
- Elevation (deg);
- X position (nmi);
- Y position (nmi);
- Time (sec);
- Target id;
- Scan number; and
- Standard Deviation.

This information is read into the table by RSIM routine.

(b) Association Flag (Each unused plot is marked by the CORR routine).

Note that the plots from the current scan are passed to INIT routine by the FRAME in the A(0:500,15) array.

A new array of B(n, 0:500, 15), which keeps the returns from a defined number of previous scans, will be maintained by the INIT module. (n is the number of the scans. This number will be determined before the detail design stage).

Outputs:

(1) Updated NEW_TRACK table: This structure of interface will remain unchanged. However, the number of tracks it holds will be increased from 50 to 500.

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(2) Updated B array: The radar plots will be stored for a defined number of scans in this array. After the initiation routine the contents of this array will be modified.

Algorithm:

* Store a defined number of scans of measurements in the table (array B(n, 0:500, 15));

* If the radar plots are stored for n number of scans process the following:

  - Build the histogram by calculating ρ_i associated with each θ_i using the formula

$$\rho_i = x\cos\theta_i + y\sin\theta_i$$

Points from previous scans	θ_i (rad)				
	θ_1	θ_2	θ_3	...	θ_n
(x_1,y_1)	ρ_{11}	ρ_{12}	ρ_{13}	...	ρ_{1n}
(x_2,y_2)	...	...	...	...	...
...	...	...	...	...	...
(x_n,y_n)	ρ_{n1}	...	...	...	ρ_{nn}

  - Register for each bin, the number of counts of same or close (in a defined threshold) ρ values. The mean and the variance values will be calculated for each bin . The tracks will be identified whose variances are lower than the determined threshold. This threshold will depend on the accuracies of the radars and will be considered as a design parameter and determined in the design stage.

  - If the number of counts in a bin identified in the previous step, exceeds the threshold set for the number of counts (will represent a track), process of straight line fitting to a set of data points will be performed

    - Points occurred due to noise or crossing tracks are eliminated by examining the time stamp associated with the plots

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- Points in adjoining histogram bins that satisfy a distance criterion (will be determined) are added according to the time stamp

- ρ_o and θ_o are calculated using N points assigned to the line and solving for the parameter values that minimize the total distance

$$D^2 = \sum_{i=1}^{N_L} (\rho - x_i\cos\theta - y_i\sin\theta)^2$$

- Prediction could be done by using the line equation (optional)

- The points used to create tracks are eliminated from the table

2.2.3 Track Initiation Based on Sequential Processing (Logic-Based)

Logic based track initiation is done by using two search techniques:

(1) General Search
(2) Parallel Search

Parallel Search Technique

This technique assumes that the targets in the neighbourhood of the measurement move approximately with the same velocity. The association window around an unused plot could be created by using the velocity from an established track with come uncertainty added on the velocity. By applying parallel search technique, the search for other potential tracks is reduced.

Example:

Tracks	Unused Plots	Track1 Window	Track2 Window
track1	plot1	plot1	plot4
track2	plot2	plot2	
	plot3		
	plot4		

At the current scan, there are two plots (plot1 and plot2) which fall into the track 1 window. The correlation routine (CORR) associates plot1 with track

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2 (based on nearest neighbourhood routine). Since plot 2 was also in the same window, by applying parallel search technique, the acceptance window for plot 2 could be built for the next scan by using track 1's velocity with some uncertainty.

Upon exiting CORR routine:

- plot 1 will be used to update track 1
- plot 4 will be used to update track 2
- plot 2 will be marked as unused and also the velocity and id is recorded in the table
- plot 3 will be marked as unused

The next scan, the initiation routine processes the parallel tracks first (namely, plot 2 from previous scan). The remaining unused plots will be processed by using the general search technique which initializes a potential track based on 3 scans data and confirms it after 5-8 scans. Any potential track, initialized by the parallel or general search technique is confirmed after 5-8 scan depending on the clutter density. The number of scans required for the confirmation (5-8) will be defined in the later stage.

Following section briefly describes the General Search Technique.

General Search Technique

This technique is applied to the unused plots of the current scan which are not eliminated by the parallel search algorithm. Tracks are generated by associating measurements from the first scan to each candidate from the second scan using an acceptance region. The acceptance region is built by using the motion of the target, characterized by a maximum and minimum velocity. d_{ij}^{l}, the component l of the distance vector between measurements $z_i^l(1)$ and $z_j^l(2)$ is defined as

$$d_{ij}^{l} = [z_j^l(2) - z_i^l(1) - v^l_{max}\Delta]^+ + [z_j^l(2) - z_i(l) - v^l_{min}\Delta]^-$$

where $[x]^+ = \max[x,\phi]$,
$[x]^- = \max[-x,\phi]$

Δ is the time interval between the scans

$z_i^l(k)$ is the component l of the measurement i at time k
$k = 1,2$

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v^l_{max}, v^l_{min} is the maximum and the minimum velocity respectively, for coordinate l.

Then assuming the measurements errors to be independent, normal and zero-mean with covariance $R_i(k)$, the normalized distance squared, D_{ij}, will be the test statistics.

$$D_{ij} = d_{ij}' \, [R_i(1) + R_j(2)]^{-1} \, d_{ij}$$

The test for associating $z_i(1)$ to $z_j(2)$ is $D_{ij} \leq \mu$

where μ is a threshold obtained from the tables of chi-square distribution. (μ will be specified in the design stage).

These two search techniques will be used to associate (or correlate) measurements from the subsequent scans by applying polynomial fitting algorithm. The straight line extrapolation (First Order Polynomial) is used to calculate the estimates and the predictions as follows when only two scans of information available:

Estimates:

$$P(k) = \frac{\sigma^2}{k} \begin{bmatrix} 1 & 0 \\ 0 & \frac{12}{(k-1)(k+1)T^2} \end{bmatrix}$$

$$\begin{bmatrix} \hat{a}_0(k) \\ \hat{a}_1(k) \end{bmatrix} = \sigma^{-2} P(k) \begin{bmatrix} \sum_{i=1}^{k} z(i) \\ \sum_{i=1}^{k} z(i)\, t_i \end{bmatrix}$$

where $\hat{a}_o(k)$ and $\hat{a}_1(k)$ are position and velocity estimates, respectively.

Predictions:

$$x(t \mid k) = \phi(t)\hat{a}(k)$$
$$P(t \mid k) = \phi(t) P(k) \phi(t)' \quad \text{where} \quad \phi = \begin{bmatrix} 1 & t \\ 0 & 1 \end{bmatrix}$$

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The estimated values and the predictions into the next scan can be done using the Second Order Polynomial fit when there are three consecutive scans of information available. The estimates are calculated as:

$$\hat{A}(k) = \begin{bmatrix} \hat{a}_0(k) \\ \hat{a}_1(k) \\ \hat{a}_2(k) \end{bmatrix} = \sigma^{-2} P(k) \begin{bmatrix} \sum_{i=1}^{k} x(i) \\ \sum_{i=1}^{k} x(i)\, t(i) \\ \sum_{i=1}^{k} x(i)\, \frac{t_i^2}{2} \end{bmatrix}$$

$$P(k) = \sigma^2 \begin{bmatrix} \frac{3(3k^2-7)}{4k(k^2-4)} & 0 & -\frac{30}{k(k^2-4)T^2} \\ 0 & \frac{12}{k(k^2-1)T^2} & 0 \\ -\frac{30}{k(k^2-4)T^2} & 0 & \frac{720}{k(k^2-1)(k^2-4)T^4} \end{bmatrix}$$

where $\hat{a}_0(k)$ and $\hat{a}_1(k)$ and $\hat{a}_2(k)$ are the position, velocity and acceleration estimates, respectively.

The predictions into the next scan are calculated as:

$$\hat{x}(t \mid k) = \phi(t)\, \hat{A}(k)$$
$$P(t \mid k) = \phi(t)\, P(k)\, \phi(t)'$$

where

$$\phi = \begin{bmatrix} 1 & t & \frac{t^2}{2} \\ 0 & 1 & t \\ 0 & 0 & 1 \end{bmatrix}$$

The tracks with miss detections over a certain number will be deleted. This number is a design parameter and will be determined in a later stage.

INIT Module

A new initialization routine (INIT) will be written to incorporate the Sequential Processing (Logic-Based) track initiation technique to the ATP package.

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A new array which keeps the potential tracks (PREL_TRACK), will be created. The information on the potential tracks will be kept in this array for 5-8 scans.(The number of scans changes between 5 to 8 depending on the clutter density, and will be determined at the design stage.

This PREL_TRACK array will be defined as follows:

PREL_TRACK(size,15)

The size is considered as a design parameter and will be specified in the detail design stage depending on the clutter density.

Note that this array is only accessed and maintained by the INIT routine.

Inputs:

(1) Unused plots from the previous scan (not associated with any tracks in the global track database); and

(2) Unused plots from the current scan (not associated with any tracks in the global track database).

The information stored in these two tables corresponding to each plot can be listed as:

(a) Measurement data (data read form the radar data file)
- Range (nmi);
- Azimuth (deg);
- Elevation (deg);
- X position (nmi);
- Y position (nmi);
- Time (sec);
- Target id;
- Scan number; and
- Standard Deviation.

This information is read into the table by RSIM routine.

(b) Association Flag (Each unused plot is marked by the CORR routine)

(c) Additional Init Information: This information is entered by the CORR routine as a result of parallel search algorithm. (Defined in the following section). If this plot belongs to a parallel track, the related

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track number and velocity is entered for the next scan association region set up.

Note that the plots from the current scan are passed to INIT routine by the FRAME in the A(0:500,15) array.

A new array of B(0:500, 15), which keeps the returns from a defined number of previous scans, will be maintained by the INIT module.

Outputs:

(1) Updated NEW_TRACK table: This structure of interface will remain unchanged. However, the number of tracks it holds will be increased from 50 to 500.

(2) Updated B array: The radar plots of the previous scan will be stored in this array. After the initiation routine the contents of this array will be modified by copying the unused (not used in the track maintenance or in the track initiation modules) measurements of the A array to the array B.

Algorithm:

(1) Apply the parallel search algorithm to correlate the measurements of the current scan to the marked measurements of the previous scan. (These measurements are marked by CORR algorithm in the previous scan. The association window for these measurements are created as described in the section of the Parallel Search Technique.)

(2) Apply the general search algorithm to associate the measurements from the current scan to the measurements from the previous scan. The association window for the general search technique are built as described in the section of General Search Technique.

(3) For the potential tracks which are started either by using general or parallel search technique apply the following logic:

(3.1) For every potential track, consisting of two measurements a straight line extrapolation (First Order Polynomial) is used to calculate the estimates and the predictions.

(3.2) In the third scan, the acceptance region is built around the predicted values.

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- If no plots fall into this window then this track is dropped.

- If more than one plot fall into the window, then track is split

The estimated values and prediction into the next scan can be done using either the first or the second order polynomial fit since we have three measurements from the previous scans.

(3.3) Check the age of the potential track. (Note that the age is set to 0 when the track is first initiated). If the age in scans is greater than a set number (5-8 scans), then record this track in the NEW_TRACK array to be created in the global TRACK table.

(4) Copy the unused measurements to the B(0:500,15) array for the next scan initiation process.

CORR Module

The CORR routine correlates the measurements from the current scan to the existing tracks. This routine will be modified to implement the parallel search algorithm. If there are more than one measurement which fall into the track's association window, this routine assigns only one measurement to each track by using Nearest Neighbourhood Elimination. In order to implement the parallel search algorithm following logic will be added:

* If there are more than one plot in the track's association window,

  - use the Nearest Neighbourhood Algorithm to assign only one measurement to the track; and

  - For the rest of the plots which are in the association window but not correlated with the track, mark the track's velocity and track id in the corresponding location of A array. This information is used by the new INIT routine.

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3 PERFORMANCE SPECIFICATIONS

3.1 Track Initiation Techniques

The track initiation in the current version of the ATP package is performed from the three consecutive plots which yield a stable course. The stability of the course is determined by comparing the calculated speed and acceleration against the preset values of the speed and acceleration. The selection of the preset values plays an important role on the performance of the track initiation technique.

Following is the list of performance criteria to be used in the Evaluation of the Track Initiation Techniques, Task III of MTT - Phase II.

(1) Number of Tracks Initiated;
(2) Creation Time of Tracks (early or late response);
(3) Elimination of Clutter;
(4) Processing Time, Speed;
(5) Average Track Quality over normalized distance; and
(6) Average Track Life.

All three techniques will be exercised against the RATT radar data collected at Cold Lake, Alberta, SSR tracks (TRAC52, STD data file) will be used to evaluate the performance for the criteria 1, 2, 5 and 6. For the criteria 3 and 4, the initiation techniques will be tested against the ASR data (both clutter and track data).

Following paragraphs describes the performance issues of the different initiation routines.

Hough Transform Track Initiation

This technique ensures guaranteed multiple track initiation in a dense clutter environment. Therefore, it is expected to get a better performance in clutter elimination, by applying Hough Transform Technique.

Following parameters used in this technique play an important role on the performance of the Hough Transform Track Initiation.

* Number of scans (to be used for initiation);
* Error threshold and vote thresholds; and
* Quantization (parameter spacing).

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Different values of the above parameters will be used to assess the performance of the technique.

Sequential Processing Track Initiation

In this technique, the track initiation process uses an initiation window based on the measurement covariance and the calculated target kinematics. Ideally, this approach will yield better performance than using a preset speed and acceleration values (as in current INIT routine in the ATP package).

The tracking packages which uses Sequential Processing Track Initiation technique spend more time and effort on the initiation process. However, in a cluttered environment 5-8 scans of preliminary track processing ensures guaranteed track initiation in the global track database. This technique is best employed in the parallel processing systems.

Following parameters used in this technique play an important role on the performance of the Logic-Based Track Initiation.

* Speed thresholds (max and min target speeds); and
* Number of scans (for track confirmation).

Different values of the above parameters will be used to assess the performance of the technique.

3.2 Memory Requirements

To evaluate the new techniques in a dense clutter environment, ATP software will be modified in order to process up to 500 new returns per scan and 500 tracks. The impact of this requirement on the memory storage is as follows:

Current Version of Track Initiation with Increased Array Sizes

Current Version	Increased Sizes
A(0:50, 0:50, 10)	A(0:500, 0:500, 10)
B(0:50, 0:50, 10)	B(0:500, 0:500, 10)
NEW_TRACKS(50,7)	NEW_TRACKS(500,7)
TRACK(100,123)	TRACK(800,123)
App. 253 Kb	App. 20 MB

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Hough Transform Track Initiation with Increased Array Sizes

A(0:500, 15)
B(n, 0:500, 15) B(0: n*500, 15) where n = 5
NEW_TRACKS(500,7)
TRACK(800,123)
HIST (0: N*500, 30)

App. 867 Kb

The histogram created for this technique, uses a big chunk of the memory depending on the resolution used. This is considered as a design parameter and will be defined in a later stage of the project.

Sequential Processing Track Initiation with Increased Array Sizes

A(0:500, 15)
B(0:500, 15)
NEW_TRACKS(500,7)
TRACK(800,123)
PREL_TRACK(1000,15)

App. 520 Kb

3.3 Processing Requirements

The processing time of the Hough Transform track initiation routine will be expected to be longer than the currently used algorithm due to the heavy computational requirements. The processing time changes according to the resolution employed. The details of the resolution procedure will be determined later. Also this technique is employed after defined number of scans (4 or more). Therefore there will be an idle period, before each track initiation.

The processing time for the sequential processing track initiation will also be longer than the current initiation routine due to the general search algorithm. However, it is possible to use early pruning in the general search algorithm to shorten the processing time. This is considered as a design issue and will be addressed in a later stage.

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Due to the nature of the technique used, the tracks are initiated in 5-8 scans. Therefore, the initiation of the tracks in the global database will take longer time than the current version of initiation routine.

The increase in the array sizes in order to process more returns and tracks per scan due to the clutter environment will increase the processing time of all the routines by a certain ratio. On the other hand, the capability of handling a dense clutter environment will be added to the ATP package.

4 DESIGN REQUIREMENTS

All the modifications and the new modules will be implemented in FORTRAN on VAX and will be compatible with the Radar Division Micro_VAX Computer.

PC - MATLAB, Version 3.05 will be used to generate the graphs for the performance analysis.

The design of the new modules and the all the modifications will be documented in the Software Design Document in the Task II of the project.

5 ATP SYSTEM INTEGRATION AND TESTING

The current ATP package will be modify to accommodate the interface changes as described in the Operating Functions Section and a new version will be created. This version of the ATP package will be used as a baseline test-bed to create the new track initiation modules.

The new track initiation modules will be used in different runs by keeping the other modules of the tracker unchanged to test the performance of the different techniques. A new version of the ATP will be built to include different track initiation techniques.

The techniques are codes in the following files:

* Hough Transform Track Initiation: Hough init.for;
* Logic-Based Track Initiation: Logic init.for; and
* Original ATP Track Initiation: Kod init.for.

ATP built has to include the one of the above files for the track initiation.

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The global variables defined for each technique are included by the initiation file and are used only in initiation process to keep ATP as modular as possible.

The new initiation routines and all the other modifications will be tested against a set of radar data simulating the dense clutter environment, in the ATP environment. The results will be analyzed and documented against the set performance criteria.

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ANNEX A

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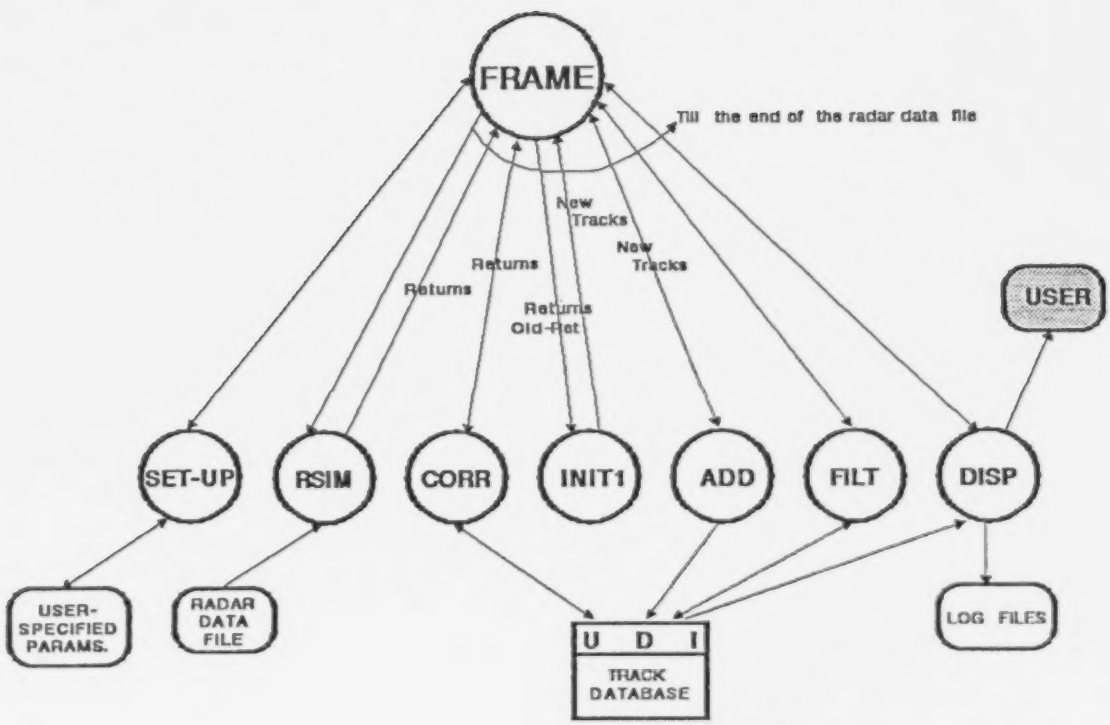

FIGURE ATP PACKAGE

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Multi-Target Tracking, Automatic Tracking Testbed, Track Initiation Techniques, Hough Transform, Logic Based, Sequential Processing.

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